

SPECIAL NOTE FOR QC/QA SPECIFICATIONS FOR CLASS P CONCRETE

This Special Note will apply where indicated on the plans or in the proposal. Section references herein are to the Department's current Standard Specifications for Road and Bridge Construction.

1.0 DESCRIPTION. This Special Note specifies the process control and acceptance testing for Class P Concrete (JPC pavement, shoulders, base). JPCP 24/48/72 will not be included under this note. Perform work and furnish materials according to the Department's Standard Specifications with the following exceptions and additions. Perform both process control and acceptance testing. Minimum test frequencies are provided. The Department will only perform verification testing.

2.0 MATERIALS. Conform to Subsection 501.02 or 601.02.

3.0 PROCESS.

3.1 Quality Control Plan (QCP). Submit the QCP checklist to the Engineer for review and approval at least 15 calendar days prior to commencing concrete operations. The QCP is the responsibility of the Contractor and should be a joint effort between the Contractor and any subcontractors. Submit a revised QCP for review and approval if any changes are necessary.

3.2 Contractor Requirements.

- 1) Select a concrete production facility that conforms to the production requirements found in Subsection 601. If the facility fails to meet these requirements during production and is no longer qualified to supply concrete the Contractor is solely responsible for obtaining the services of another concrete production facility to continue placement of concrete on the project.
- 2) Provide concrete technicians that are certified as ACI Level I Concrete Field Testing Technicians.
- 3) Provide an AASHTO accredited or Kentucky Transportation Cabinet qualified laboratory facility.
- 4) Job Site Acceptance Requirements:
 - a) Trip Tickets. Collect trip tickets for each load of concrete. Check each truck mixer for a current performance test sticker and the metal plate stating manufacturers recommended capacities and revolution speeds. Verify and/or record the following for each load of concrete delivered to the project:
 - Age of mix
 - Mixing revolutions recorded on the trip ticket
 - Discharge time
 - Addition of water
 - Additional mixing revolutions if water is added
 - Job site test data

The Technician shall reject concrete failing to meet the requirements for any item.

- b) Technician Responsibilities. ACI Level I Concrete Technicians shall be on site to inspect all quantities of concrete delivered to the project. Inspection responsibilities include field tests for slump, air content, temperature, and casting of cylinders of the plastic concrete. All testing shall be performed according to the applicable Kentucky Methods. The Technician shall reject concrete failing to meet the requirements of any of these tests.

5) Testing:

- a) Start Up Test Frequencies. Perform start-up slump, air content, and temperature tests each day of placement for Class P concrete. The minimum frequency is the first unit and any one of the next 4 Units

The First Unit is the first load delivered producing acceptable start up test results. For example; if the first load of the day produces failing test results, it is rejected. Repeat Start Up Tests for the second load delivered. If the second load produces passing test results it is accepted and considered the First Unit.

- b) Acceptance Testing. Provide test equipment conforming to requirements of the appropriate test method. The Engineer may inspect and reject any equipment found defective.

- Sample and test the plastic concrete for air content, slump, and temperature at the point of placement. Once the First Unit has been established, the Department will include all randomly selected samples for payment in the pay factor calculations even if the unit is out of specification. If any randomly selected production unit is outside the specification limits for slump, temperature, or air content, return to the start-up testing frequency.
- Mold a minimum of one set of cylinders at the point of placement for each subplot (see Subsection 3.2-5-c of this Special Note) for compressive strength testing. A “set” of cylinders is outlined in KM 64-305. Randomly sample and test when the Engineer directs. (See the following note)
- Obtain samples anytime visual inspection of the delivered concrete indicates questionable specification compliance.
- Perform compressive strength testing on certified or Department approved machines.
- Notify the Engineer at least 24 hours prior to the time of compressive strength testing so that the test may be witnessed. The Department will witness and document a minimum of 75 percent of the tests.
- Core any concrete meeting the criteria for investigation of in-place concrete based on low cylinder strengths (see 3.2-6). When coring is required, furnish equipment and personnel necessary to obtain and test cores. Core diameter will be as required by the Department.

Note: Number cylinders for strength testing according to the following format unless otherwise approved by the Engineer:

Lot # - Sublot # - Class of Concrete

If a set of cylinders are made for early breaks, follow the class of concrete with an “X”. The verification cylinders made by the department will use a

“V” after the class of concrete.

- c) **Lot Size.** Lots and sublots will be based on delivered quantities in lieu of design quantity. Lots are defined as 4,000 square yards. Lots are divided into 4 sub-lots of 1,000 square yards.

Use the following table in determining concrete quantities and their corresponding lots and sublots.

Square Yards	Total Sublots – Equally Divided
< 2,000	Accept based upon plastic concrete test results plus one set of cylinders if more than 15 cubic yards per calendar day*
$2,000 \leq 4,000$	4
$4,000 \leq 5,000$	5
$5,000 \leq 6,000$	6
$6,000 < 8,000$	One standard lot, plus a second smaller lot with 4 sublots.

* PWL and incentive/disincentives are not applied but accepted at 100% pay based on achieving acceptable results.

NOTE: All early strength modified mixes will be combined, if quantities are available, to make a lot(s).

- d) **Documentation.** Record all job site test results when obtained. Provide a summary of test results and trip tickets at least weekly to the Engineer. In the summary, include a record of all concrete rejected. As 28-day breaks are obtained, submit air and strength results along with corresponding random numbers and subplot/lot identification at the completion of each and every lot. Report all failing compressive strength tests to the Engineer as soon as possible, but no later than the end of the testing day.
- e) In addition to acceptance testing, perform all sampling, testing (slump, air, temperature and strength) for the purpose of either load applications, or opening to traffic. These results are to be kept separate from random QC results and are not to be used for pay calculations.
- f) Additional acceptance sampling testing by the Contractor is permitted but must be included in the QCP by reducing size of sublots within the lots (3.2-5-c) to be included in pay calculations.
- 6) **Investigation of In-Place Concrete.** The Department will require a core evaluation of the in-place concrete when any of the following occur:
- An individual test result falls more than 500 psi below minimum required compressive strength
 - Strength PWL for a lot is less than 75
 - Air content PWL below 60 will require special evaluation by the Engineer based on core testing (hardened air content) to determine acceptance/rejection, and any corrective work needed.
 - Any lot missing more than 25% of the required tests for strength or air will require coring and testing. The results will be evaluated according to (3.4-2).

The investigation will take place at the direction of the Engineer. Obtain cores within 7 calendar days of written notification.

3.3 Concrete Producer Requirements. Requirements include mix design, testing, documentation, plant approval, and truck approval in accordance with Section 601. Mix Designs. Submit mix designs to the Engineer using either Option A or Option B below.

- 1) Option A. Kentucky Mix Design. Submit mix designs according to Subsection 601.03.02 G at least 15 calendar days prior to commencing concrete operations. Design and proportion the concrete mixtures according to Subsection 601.03.03. Resubmit the mix designs when changes are made.
- 2) Option B. ACI-318 Mix Design. Comply with ingredient material specifications and mineral admixture limitations according to the Department's Standard Specifications. Conform to the following if requirements are not modified elsewhere by plan note.

Max. Free Water By w/c Ratio (lbs/lbs)	Min. 28-Day Comp. Strength (psi)	Air Content (%)
0.49	3,850	6± 2% *

* The air content shall be $7 \pm 2\%$ when coarse aggregate sizes #8, #78, or #9-M are used.

3.4 Department Responsibilities.

- 1) Concrete Mixture Verification Testing. The Engineer will conduct verification testing to verify acceptance procedures. Only ACI Level I qualified personnel will perform the verification testing. The Engineer will determine according to KM 64-113 when the Contractor is to perform random sampling and testing. The Engineer will notify the Contractor immediately prior to required random sampling and testing.

The Engineer will test at a minimum frequency of one per every 8 acceptance tests made by the contractor. The Engineer reserves the right to increase the frequency of testing when deemed necessary. The Engineer will perform verification testing on independent samples from the same batch and location as the Contractor's tested subplot and promptly compare results. Additionally, the Engineer may select any portion of any subplot at any time to verify specifications limits. All verification cylinders will be the same size as the contractors acceptance cylinders.

When the verification test results differ from the Contractor's test results by more than tolerances shown below, the discrepancy must be resolved and documented along with the verification results. The dispute resolution outlined in Section 113 will be utilized to verify the acceptability of the concrete.

The Department will witness and document a minimum of 75 percent of the tests.

Acceptance/Verification Tolerance*	
Test	Tolerance
Air Content	$\pm 0.75\%$
Compressive Strength	$\pm 15\%$
Temperature	$\pm 3^\circ \text{F}$
Slump	$\pm 25\%$ of maximum limit

*These tolerances only apply to verification samples

- 2) Core Evaluation for Class P Concrete. When investigation is required according to 3.2-6 of this note, the Engineer will direct the Contractor in obtaining cores and take possession of the cores for testing. All expenses in obtaining and testing cores will be the responsibility of the contractor. The Engineer will evaluate cores as follows:
 - a) If core strengths are equal to or greater than 90 percent of minimum required compressive strength, the core strengths will be substituted for the low/missing cylinder(s) to determine PWL. Lots affected will not be eligible for incentive adjustments but may achieve 100 percent maximum pay.
 - b) If core strengths are below 90 percent of minimum required compressive strength, a design analysis will be required to determine if strength is adequate.
 - 1) If strength is determined to be adequate, the core strengths will be substituted for the low/missing cylinder(s) to determine PWL.
 - 2) If strength is determined not to be adequate, the lot or sublot containing the failing concrete shall be removed and replaced at the Contractor's expense. The Contractor may be given the option of obtaining additional cores to more accurately identify the extent of removal required.
 - c) If the hardened air content is found to be acceptable, the air results will be substituted for the failing/missing air result to determine PWL. Lots affected will not be eligible for incentive adjustments but may receive 100 percent maximum pay.
 - d) If the hardened air content is found to be unacceptable, the concrete is subject to removal.

4.0 MEASUREMENT.

4.1 Class P (JPC Pavement, Base, and Shoulders). The Department will measure JPC Pavement, Base, and Shoulder according to Subsections 501.04.01, 501.04.02, and 501.04.03 respectively.

The Department will not measure the strength and air content of the pavement concrete as a separate pay unit, but will analyze the strength and air content data as provided by Contractor to calculate pay factors for each separate lot of JPC Pavement, Base, and Shoulders.

4.2 Measurement of Dispute Items. Disputed items may require a third party resolution by a mutually agreeable laboratory. If the independent laboratory testing and investigation indicates that the Department's tests are correct, pay the cost of the

investigation. If the independent laboratory testing and investigation indicates that the Department's tests are not correct, the Department will pay the cost of the investigation.

When the dispute is resolved at any level, and the Department's verification tests are correct, the Department will base the Contractor's pay on the Department's verification test results rather than on the Contractor's acceptance test results. When the Department's verification tests are not correct, the Department will base the Contractor's pay on the Contractor's test results as the appropriate section or subsection specifies.

4.3 Measurement of Quality Control (QC). The Department will measure the quantity by the lump sum. The Department will not measure the QCP, any actions and personnel required to carry out the QCP, any testing, any testing equipment, or any other work necessary to perform the specified QC/QA procedures and will consider them incidental to this item of work.

5.0 PAYMENT. The Department will calculate pay factors for Class P Concrete only, and will apply them on a lot basis. The Department will apply Concrete QC/QA incentive/disincentive adjustment as a one-time Concrete Adjustment prior to final payment. When net bonuses exceed net penalties for concrete for the total project, the Department will pay the net difference. When net penalties, derived from Percent Within Limits (PWL) and incentive/disincentive calculations, exceed net bonuses for concrete for the total project, the Department will deduct the net difference. For concrete not requiring PWL and incentive/disincentive calculations, the Department will apply penalties according to the appropriate subsection or application. Additional pay adjustments may be applicable for concrete pavement thickness and ride quality in accordance with the Special Notes or Standard Specifications.

<u>Code</u>	<u>Pay Item</u>	<u>Pay Unit</u>
----	JPC Pavement Non-Reinforced, Thickness	See Subsection 501.05
----	JPC Pavement Shoulder Non-Reinforced, Thickness	See Subsection 501.05
----	JPC Base Non-Reinforced, Thickness	See Subsection 501.05
----	Dispute Resolution	See Appropriate Subsection
----	QC	Lump Sum
----	Concrete Adjustment ⁽¹⁾	Each

⁽¹⁾ The Department will determine pay factors and adjust the price based on the strength and air content of the concrete.

March 1, 2004

**Procedures for Percent Within Limits (PWL)
and Pay Factor Calculations**

The Contractor's QC testing data must be validated by the Department's verification tests. A percent within limit (PWL) analysis is used to determine how various specified limits are met by the Contractor. The procedure calls for determining the mean and standard deviation of acceptance data. Determine the following quality indices based upon the mean, standard deviation and upper/lower specification limits. The upper/lower limits for air content PWL calculations will be $\pm 2.0\%$ of the target air content for Class-P Concrete. If there is no upper specification limit (e.g. compressive strength), the upper quality index will be considered 100% within limits.

$$Q_u = (\text{Upper Specification Limit} - \text{Average}) / \text{Standard Deviation}$$

$$Q_L = (\text{Average} - \text{Lower Specification Limit}) / \text{Standard Deviation}$$

Where:

$$\text{Standard Deviation} = [\text{Sum}(\text{Individual Measurement} - \text{Average})^2 / (n-1)]^{1/2}, \text{ and}$$

n = Number of Measurements.

There will be 2 sets of Q_u 's and Q_L 's calculated for the air content. The first set will be calculated based on the range of $\pm 2.0\%$ if the target air percentage, with the upper limit shown as:

$$Q_u = \{(\text{Target Air \%} + 2.0) - \text{Average Air \%}\} / \text{Standard Deviation of the air content}$$

The second set will be calculated on a target of $\pm 1.0\%$ of the target air percentage, with the upper limit shown as:

$$Q_u = \{(\text{Target Air \%} + 1.0) - \text{Average Air \%}\} / \text{Standard Deviation of the air content}$$

These values will be used to derive separate PWL's and then these PWL's will be used to obtain the combined air pay factor.

Use the values for the Q_u , and Q_L and enter in the PWL tables and determine PWL_u , and PWL_L , respectively. If the values for Q_u or Q_L are determined to be negative, follow the directions given on the PWL tables. Round-off the calculated numbers to 2 decimal places.

Determine the total PWL for each specified requirement using the following relationship.

$$PWL = (PWL_u + PWL_L) - 100$$

The PWL for each specified requirement per lot is then used to determine the lot's acceptance/rejection status and its appropriate pay factor.

The Combined Air Content Pay Factor will be calculated as:

$$((25 + (PWL_{@ \pm 2} * 0.25)) + (0.0125 * PWL_{@ \pm 1})) / 100, \text{ and the Strength Pay Factor will be calculated as } ((26.25 + (0.25 * PWL)) / 100$$

Lot Pay Factor will be calculated as: (Air Pay Factor+Strength Pay Factor)

The lowest Pay Factor will be limited to 0.85 for Class-P Concrete.

Missing Data:

The first subplot missing test results per project will be permitted with no reduction in pay. The lot will be calculated based on the remaining test results if the sample size is three or more. The second subplot missing test results will require a 10% deduct for that lot. All additional sublots missing data will receive a 25% deduct applied to the lot for each subplot missing data.

Any lot missing more than 25% of the required tests for strength or air will require coring and testing. The results will be evaluated according to (3.4-2).

NOTE: All calculations are rounded to 2 decimal places except the Lot Pay Factor and the Project Pay Factor which are carried to 6 decimal places.

Table A-1. Percent Within Limits (PWL) for Selected Sample Sizes (N).
(Courtesy of FHWA-SA-96-026, 1996)

PERCENT WITHIN LIMITS ESTIMATION TABLE
VARIABILITY-UNKNOWN PROCEDURE
STANDARD DEVIATION METHOD
SAMPLE SIZE 3

Q	<i>Second Decimal Places For Q</i>									
	<i>0.00</i>	<i>0.01</i>	<i>0.02</i>	<i>0.03</i>	<i>0.04</i>	<i>0.05</i>	<i>0.06</i>	<i>0.07</i>	<i>0.08</i>	<i>0.09</i>
0.00	50.00	50.28	50.55	50.83	51.10	51.38	51.65	51.93	52.21	52.48
0.10	52.76	53.04	53.31	53.59	53.87	54.15	54.42	54.70	54.98	55.26
0.20	55.54	55.82	56.10	56.38	56.66	56.95	57.23	57.51	57.80	58.08
0.30	58.37	58.65	58.94	59.23	59.51	59.80	60.09	60.38	60.67	60.97
0.40	61.26	61.55	61.85	62.15	62.44	62.74	63.04	63.34	63.65	63.95
0.50	64.25	64.56	64.87	65.18	65.49	65.80	66.12	66.43	66.75	67.07
0.60	67.39	67.72	68.04	68.37	68.70	69.03	69.37	69.70	70.04	70.39
0.70	70.73	71.08	71.43	71.78	72.14	72.50	72.87	73.24	73.61	73.98
0.80	74.36	74.75	75.14	75.53	75.93	76.33	76.74	77.16	77.58	78.01
0.90	78.45	78.89	79.34	79.81	80.27	80.75	81.25	81.75	82.26	82.79
1.00	83.33	83.89	84.47	85.07	85.69	86.34	87.02	87.73	88.49	89.29
1.10	90.16	91.11	92.18	93.40	94.92	97.13	100.00	100.00	100.00	100.00

Numbers in the body of this table are estimates of percent within limits (PWL) corresponding to specific values of Q, the QUALITY INDEX. For Q values less than zero, subtract the table value from 100.

Table A-2. Percent Within Limits (PWL) for Selected Sample Sizes (N)
(Courtesy of FHWA-SA-96-026, 1996)

PERCENT WITHIN LIMITS ESTIMATION TABLE
VARIABILITY-UNKNOWN PROCEDURE
STANDARD DEVIATION METHOD
SAMPLE SIZE 4

Q	<i>Second Decimal Places For Q</i>									
	<i>0.00</i>	<i>0.01</i>	<i>0.02</i>	<i>0.03</i>	<i>0.04</i>	<i>0.05</i>	<i>0.06</i>	<i>0.07</i>	<i>0.08</i>	<i>0.09</i>
0.00	50.00	50.33	50.67	51.00	51.33	51.67	52.00	52.33	52.67	53.00
0.10	53.33	53.67	54.00	54.33	54.67	55.00	55.33	55.67	56.00	56.33
0.20	56.67	57.00	57.33	57.67	58.00	58.33	58.67	59.00	59.33	59.67
0.30	60.00	60.33	60.67	61.00	61.33	61.67	62.00	62.33	62.67	63.00
0.40	63.33	63.67	64.00	64.33	64.67	65.00	65.33	65.67	66.00	66.33
0.50	66.67	67.00	67.33	67.67	68.00	68.33	68.67	69.00	69.33	69.67
0.60	70.00	70.33	70.67	71.00	71.33	71.67	72.00	72.33	72.67	73.00
0.70	73.33	73.67	74.00	74.33	74.67	75.00	75.33	75.67	76.00	76.33
0.80	76.67	77.00	77.33	77.67	78.00	78.33	78.67	79.00	79.33	79.67
0.90	80.00	80.33	80.67	81.00	81.33	81.67	82.00	82.33	82.67	83.00
1.00	83.33	83.67	84.00	84.33	84.67	85.00	85.33	85.67	86.00	86.33
1.10	86.67	87.00	87.33	87.67	88.00	88.33	88.67	89.00	89.33	89.67
1.20	90.00	90.33	90.67	91.00	91.33	91.67	92.00	92.33	92.67	93.00
1.30	93.33	93.67	94.00	94.33	94.67	95.00	95.33	95.67	96.00	96.33
1.40	96.67	97.00	97.33	97.67	98.00	98.33	98.67	99.00	99.33	99.67
1.50	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Numbers in the body of this table are estimates of percent within limits (PWL) corresponding to specific values of Q, the QUALITY INDEX. For Q values less than zero, subtract the table value from 100.

Table A-3. Percent Within Limits (PWL) for Selected Sample Sizes (N).
(Courtesy of FHWA-SA-96-026, 1996)

PERCENT WITHIN LIMITS ESTIMATION TABLE
VARIABILITY-UNKNOWN PROCEDURE
STANDARD DEVIATION METHOD
SAMPLE SIZE 5

Q	<i>Second Decimal Places For Q</i>									
	<i>0.00</i>	<i>0.01</i>	<i>0.02</i>	<i>0.03</i>	<i>0.04</i>	<i>0.05</i>	<i>0.06</i>	<i>0.07</i>	<i>0.08</i>	<i>0.09</i>
0.00	50.00	50.36	50.71	51.07	51.42	51.78	52.13	52.49	52.85	53.20
0.10	53.56	53.91	54.27	54.62	54.98	55.33	55.69	56.04	56.39	56.75
0.20	57.10	57.46	57.81	58.16	58.52	58.87	59.22	59.57	59.92	60.28
0.30	60.63	60.98	61.33	61.68	62.03	62.38	62.72	63.07	63.42	63.77
0.40	64.12	64.46	64.81	65.15	65.50	65.84	66.19	66.53	66.87	67.22
0.50	67.56	67.90	68.24	68.58	68.92	69.26	69.60	69.94	70.27	70.61
0.60	70.95	71.28	71.61	71.95	72.28	72.61	72.94	73.27	73.60	73.93
0.70	74.26	74.59	74.91	75.24	75.56	75.89	76.21	76.53	76.85	77.17
0.80	77.49	77.81	78.13	78.44	78.76	79.07	79.38	79.69	80.00	80.31
0.90	80.62	80.93	81.23	81.54	81.84	82.14	82.45	82.74	83.04	83.34
1.00	83.64	83.93	84.22	84.52	84.81	85.09	85.38	85.67	85.95	86.24
1.10	86.52	86.80	87.07	87.35	87.63	87.90	88.17	88.44	88.71	88.98
1.20	89.24	89.50	89.77	90.03	90.28	90.54	90.79	91.04	91.29	91.54
1.30	91.79	92.03	92.27	92.51	92.75	92.98	93.21	93.44	93.67	93.90
1.40	94.12	94.34	94.56	94.77	94.98	95.19	95.40	95.61	95.81	96.01
1.50	96.20	96.39	96.58	96.77	96.95	97.13	97.31	97.48	97.65	97.81
1.60	97.97	98.13	98.28	98.43	98.58	98.72	98.85	98.98	99.11	99.23
1.70	99.34	99.45	99.55	99.64	99.73	99.81	99.88	99.94	99.98	100.00

Numbers in the body of this table are estimates of percent within limits (PWL) corresponding to specific values of Q, the QUALITY INDEX. For Q values less than zero, subtract the table value from 100.

Table A-4. Percent Within Limits (PWL) for Selected Sample Sizes (N)
(Courtesy of FHWA-SA-96-026, 1996)

PERCENT WITHIN LIMITS ESTIMATION TABLE
VARIABILITY-UNKNOWN PROCEDURE
STANDARD DEVIATION METHOD
SAMPLE SIZE 6

Q	<i>Second Decimal Places For Q</i>									
	<i>0.00</i>	<i>0.01</i>	<i>0.02</i>	<i>0.03</i>	<i>0.04</i>	<i>0.05</i>	<i>0.06</i>	<i>0.07</i>	<i>0.08</i>	<i>0.09</i>
0.00	50.00	50.37	50.73	51.10	51.47	51.84	52.20	52.57	52.94	53.30
0.10	53.67	54.04	54.40	54.77	55.14	55.50	55.87	56.23	56.60	56.96
0.20	57.32	57.69	58.05	58.41	58.78	59.14	59.50	59.86	60.22	60.58
0.30	60.94	61.30	61.66	62.02	62.38	62.73	63.09	63.45	63.80	64.16
0.40	64.51	64.86	65.21	65.57	65.92	66.27	66.62	66.96	67.31	67.66
0.50	68.00	68.35	68.69	69.04	69.38	69.72	70.06	70.40	70.74	71.07
0.60	71.41	71.75	72.08	72.41	72.74	73.08	73.40	73.73	74.06	74.39
0.70	74.71	75.04	75.36	75.68	76.00	76.32	76.63	76.95	77.26	77.58
0.80	77.89	78.20	78.51	78.82	79.12	79.43	79.73	80.03	80.33	80.63
0.90	80.93	81.22	81.51	81.81	82.10	82.39	82.67	82.96	83.24	83.52
1.00	83.90	84.08	84.36	84.63	84.91	85.18	85.45	85.71	85.98	86.24
1.10	86.50	86.76	87.02	87.28	87.53	87.78	88.03	88.28	88.53	88.77
1.20	89.01	89.25	89.49	89.72	89.96	90.19	90.42	90.64	90.87	91.09
1.30	91.31	91.52	91.74	91.95	92.16	92.37	92.58	92.78	92.98	93.18
1.40	93.37	93.57	93.76	93.95	94.13	94.32	94.50	94.67	94.85	95.02
1.50	95.19	95.36	95.53	95.69	95.85	96.00	96.16	96.31	96.46	96.60
1.60	96.75	96.89	97.03	97.16	97.29	97.42	97.55	97.67	97.79	97.91
1.70	98.02	98.13	98.24	98.34	98.45	98.55	98.64	98.73	98.82	98.91
1.80	98.99	99.07	99.15	99.22	99.29	99.36	99.43	99.49	99.54	99.60
1.90	99.65	99.70	99.74	99.78	99.82	99.85	99.88	99.91	99.93	99.95
2.00	99.97	99.98	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Numbers in the body of this table are estimates of percent within limits (PWL) corresponding to specific values of Q, the QUALITY INDEX. For Q values less than zero, subtract the table value from 100.

Table A-5. Percent Within Limits (PWL) for Selected Sample Sizes (N)
(Courtesy of FHWA-SA-96-026, 1996)

PERCENT WITHIN LIMITS ESTIMATION TABLE
VARIABILITY-UNKNOWN PROCEDURE
STANDARD DEVIATION METHOD
SAMPLE SIZE 7

Q	<i>Second Decimal Places For Q</i>									
	<i>0.00</i>	<i>0.01</i>	<i>0.02</i>	<i>0.03</i>	<i>0.04</i>	<i>0.05</i>	<i>0.06</i>	<i>0.07</i>	<i>0.08</i>	<i>0.09</i>
0.00	50.00	50.37	50.75	51.12	51.50	51.87	52.24	52.62	52.99	53.37
0.10	53.74	54.11	54.49	54.86	55.23	55.60	55.97	56.35	56.72	57.09
0.20	57.46	57.83	58.20	58.56	58.93	59.30	59.67	60.03	60.40	60.77
0.30	61.13	61.50	61.86	62.22	62.58	62.94	63.31	63.67	64.02	64.38
0.40	64.74	65.10	65.45	65.81	66.16	66.51	66.87	67.22	67.57	67.92
0.50	68.26	68.61	68.96	69.30	69.64	69.99	70.33	70.67	71.01	71.34
0.60	71.68	72.02	72.35	72.68	73.01	73.34	73.67	74.00	74.32	74.65
0.70	74.97	75.29	75.61	75.93	76.25	76.56	76.88	77.19	77.50	77.81
0.80	78.12	78.42	78.73	79.03	79.33	79.63	79.93	80.22	80.52	80.81
0.90	81.10	81.39	81.67	81.96	82.24	82.52	82.80	83.08	83.35	83.63
1.00	83.90	84.17	84.44	84.70	84.97	85.23	85.49	85.74	86.00	86.25
1.10	86.51	86.75	87.00	87.25	87.49	87.73	87.97	88.21	88.44	88.67
1.20	88.90	89.13	89.35	89.58	89.80	90.02	90.23	90.45	90.66	90.87
1.30	91.07	91.28	91.48	91.68	91.88	92.08	92.27	92.46	92.65	92.83
1.40	93.02	93.20	93.38	93.55	93.73	93.90	94.07	94.23	94.40	94.56
1.50	94.72	94.87	95.03	95.18	95.33	95.48	95.62	95.76	95.90	96.04
1.60	96.17	96.31	96.43	96.56	96.69	96.81	96.93	97.05	97.16	97.27
1.70	97.38	97.49	97.59	97.70	97.80	97.89	97.99	98.08	98.17	98.26
1.80	98.35	98.43	98.51	98.59	98.66	98.74	98.81	98.88	98.94	99.01
1.90	99.07	99.13	99.19	99.24	99.30	99.35	99.40	99.44	99.49	99.53
2.00	99.57	99.61	99.64	99.68	99.71	99.74	99.77	99.79	99.82	99.84
2.10	99.86	99.88	99.90	99.92	99.93	99.94	99.95	99.96	99.97	99.98
2.20	99.99	99.99	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Numbers in the body of this table are estimates of percent within limits (PWL) corresponding to specific values of Q, the QUALITY INDEX. For Q values less than zero, subtract the table value from 100.

Table A-6. Percent Within Limits (PWL) for Selected Sample Sizes (N)
(Courtesy of FHWA-SA-96-026, 1996)

PERCENT WITHIN LIMITS ESTIMATION TABLE
VARIABILITY-UNKNOWN PROCEDURE
STANDARD DEVIATION METHOD
SAMPLE SIZE 8

Q	<i>Second Decimal Places For Q</i>									
	<i>0.00</i>	<i>0.01</i>	<i>0.02</i>	<i>0.03</i>	<i>0.04</i>	<i>0.05</i>	<i>0.06</i>	<i>0.07</i>	<i>0.08</i>	<i>0.09</i>
0.00	50.00	50.38	50.76	51.14	51.51	51.89	52.27	52.65	53.03	53.41
0.10	53.78	54.16	54.54	54.92	55.29	55.67	56.04	56.42	56.79	57.17
0.20	57.54	57.92	58.29	58.66	59.03	59.41	59.78	60.15	60.52	60.89
0.30	61.25	61.62	61.99	62.35	62.72	63.08	63.45	63.81	64.17	64.53
0.40	64.89	65.25	65.61	65.96	66.32	66.67	67.03	67.38	67.73	68.08
0.50	68.43	68.78	69.13	69.47	69.82	70.16	70.50	70.84	71.18	71.52
0.60	71.85	72.19	72.52	72.85	73.18	73.51	73.84	74.17	74.49	74.81
0.70	75.14	75.46	75.77	76.09	76.41	76.72	77.03	77.34	77.65	77.96
0.80	78.26	78.56	78.86	79.16	79.46	79.76	80.05	80.34	80.63	80.92
0.90	81.21	81.49	81.77	82.05	82.33	82.61	82.88	83.15	83.43	83.69
1.00	83.96	84.22	84.49	84.75	85.00	85.26	85.51	85.76	86.01	86.26
1.10	86.51	86.75	86.99	87.23	87.46	87.70	87.93	88.16	88.39	88.61
1.20	88.83	89.06	89.27	89.49	89.70	89.91	90.12	90.33	90.53	90.74
1.30	90.94	91.13	91.33	91.52	91.71	91.90	92.09	92.27	92.45	92.63
1.40	92.81	92.98	93.15	93.32	93.49	93.65	93.81	93.97	94.13	94.29
1.50	94.44	94.59	94.74	94.88	95.03	95.17	95.31	95.44	95.58	95.71
1.60	95.84	95.97	96.09	96.21	96.33	96.45	96.57	96.68	96.79	96.90
1.70	97.01	97.11	97.21	97.31	97.41	97.51	97.60	97.69	97.78	97.87
1.80	97.96	98.04	98.12	98.20	98.28	98.35	98.42	98.49	98.56	98.63
1.90	98.69	98.76	98.82	98.88	98.93	98.99	99.04	99.09	99.14	99.19
2.00	99.24	99.28	99.33	99.37	99.41	99.45	99.48	99.52	99.55	99.58
2.10	99.61	99.64	99.67	99.70	99.72	99.74	99.77	99.79	99.81	99.83
2.20	99.84	99.86	99.87	99.89	99.90	99.91	99.92	99.93	99.94	99.95
2.30	99.96	99.96	99.97	99.98	99.98	99.98	99.99	99.99	99.99	100.00

Numbers in the body of this table are estimates of percent within limits (PWL) corresponding to specific values of Q, the QUALITY INDEX. For Q values less than zero, subtract the table value from 100.